PROBLEMS OF WATER MANAGMENT OF THIRD WORLD COUNTRIES IN HUMID TROPICAL REGIONS

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ABSTRACT Because of lack of trained manpower and funds third world countries in humid tropical areas have bad problems with water managment. The major problems faced are flooding, soil erosion and pollution. Flooding can be controled with dams and levees. Soil erosion can be controled by careful deforestation techniques, seedbed preparation, and runoff and crop managment. Pollution can be controlled by industry and government measures which is unlikely to occur because of pressure to promote industry. Pollution can be avoided in drinking water by exploitation of groundwater aquifers in place of contaminated river water.

Definition of the Humid Tropics

The areas being considered in theis paper are the humid tropical regions. They are located mainly between the Tropic of Capricorn and the Tropic of Cancer. Humid tropic regions are defined as having a mean annual precipitation of at least 1000 mm and a mean temperature in any month of at least 20 degrees Celsius (UNESCO, 1978).

The areas can be divided into two basic catagories: continually moist and seasonally moist. The continually moist areas are almost all within 5 to 10 degrees of the equator and are noted for year-round precipitation. The seasonally moist areas extend further out from the equator and are noted for seasonal precipitation due to the tilt of the earth which causes a change in the sun's position relative to the earth. The seasonally moist areas have a rainy season usually from late spring to fall. The rainy season gradually decreases in length further from the equator because the humid tropics grade slowly into more temperate zones. There is no sharp boundary for the humid tropics.

The humid tropics are almost entirely comprised of third world countries with the exception of parts of Mexico and Australia. Third world countries have serious problems with developing these humid tropic areas for three reasons:
1. Sparse population and lack of manpower, 2. Lack of funds for long term projects, 3. Lack of technically trained people.
It must be noted that an exception to the problem of population is Southeast Asia. The lower river valleys and deltas are densely

populated but the upper river and tropical forest areas of southeast Asia are for the most part sparsely populated. Figure 1 shows the distribution of humid tropical areas.

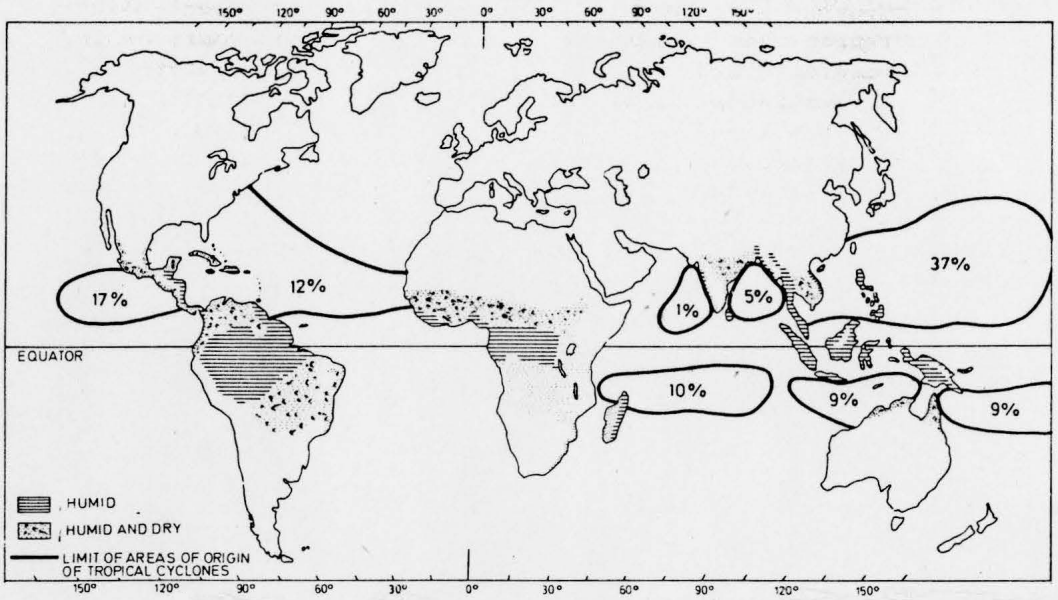

Figure 1 shows distribution of humid tropical regions and origins of tropical storms. From IAHS pub. no.140

Present Uses of Water Resources

The number one use of water is for agriculture. Since these are lesser developed countries agriculture is the backbone of their economies. Most agricultural areas get their water from rivers either by irrigation or flooding. The upper parts of the rivers are covered mostly with tropical forest but they are quickly being removed to use the land for agriculture. At present rates, by the year 2000, 40% of today's tropical forests will be cleared for agricultural use (Eckholm, 1979).

The next major use of water is human consumption. Most areas in the humid tropics have good sources of potable water

because streams in tropical forests are exceptionally clean. In the larger urban centers people depend on river water for consumption and removal of wastes.

Local industry is also very dependent on river water. Lack of technology forces industry to use river water for disposal of wastes. The problems for third world countries can be lumped into two groups. First, control of excess water to protect arable land. Second, control of the quality of runoff water used in urban centers by people and industry.

Problems in Water Managment

Flooding

Flooding is a major problem cused by excessive precipitation from tropical storms. Floods can be generalized into two types: slow rising floods and flash floods. Slow rising floods are actually important to agriculture especially in southeast Asia where farming is concentrated on deltas and in the lower river valleys. The main crop there is rice and local varieties have been developed that can grow in water with depth increasing from 5 to 10 cm. a day (Volker, 1983). Slow flooding also deposits a lot of silt and clay in the lower river valleys adding to the soil depth.

Flash floods are sudden and very destructive, causing massive removal of soil, crops and anything else in the way. They occur frequently because of groud saturation and intense tropical storms. They are more prevalent in areas of seasonal rain. They can be predicted accurately today because of the modern technology available to track tropical storms.

There are two types of control available to developing countries: upstream control and in-place control. Upstream control means the use of dams. Dams hve three large benefits: flood control, irrigation, and power generation. The problems with dams are the huge expense invloved, long term committment needed before operation begins, loss of land upstream, and lack of technically trained people to design, build and manage large scale projects. Third world countries can turn to organizations like the U.N. for help especially on international waterways. The U.N. is currently sending trained people to study the possibilities of dam construction on the Mekong river in Thailand.(Volker,1983). Dams have been constructed in Brazil with great success, but Brazil has a stronger economy and industry than other lesser developed countries.

In-place control of flooding involves the use of levees and embankments. Levees have advantages over dams in that they are cheaper, easier to construct and have more immediate results. One of the biggest problems with embankments is that during the dry season and the gentle floods of the growing season local farmers have had to breech the levees to irrigate their fields (Volker,1983). However, embankments have been used in southeast Asia for over 2000 years with great success and could be used in Africa and South America as well (Volker,1983).

Water Storage

Water storage is particularly important for the agriculture in areas of seasonal rain. In these areas the dry season can dry enough to stop crop production. If large amounts of water

are stored during the rainy season 2 to 3 crops can be grown a year instead of 1 or 2. Dams could be used but they have some big drawbacks as described earlier. Artificial and natural lakes are currently being used in all parts of the world. Where there is a good location and it is economically feasible this is a good idea. Lakes can also help with drainage by diverting runoff waters. Ground water aquifers can also be used to store water. They can be recharged quickly during wet months but commonly high amounts of silt and clay in runoff water may make this approach technically unfeasible.

Soil Erosion

Soil erosion is one of the worst problems facing third world countries today. Mismanagment of water and soil on land cleared of tropical forests has turned about 10^9 ha of land into semidesert (Lal, 1983). Land being cleared today must be well managed to stop this trend. There are two types of erosion occurring: chemical and physical.

Chemical erosion involves the leaching of valuable nutients from the soil. Because of the high temperature, biodegradation, and high amounts of precipitation leaching occurs quickly (Brinkman, 1983). Nutrients must be absorbed immediately by plants or it will be leached away. This causes the soil to be very nutrient poor, especially with magnesium, calcium, nitrogen and phosphorous. This problem is particularly acute in South American tropical forests because the soil derived from the parent rock is nutrient poor to begin with. Deforestation is usually done by the slash and burn technique. Most of the nutrients locked up in

the vegetation are lost. When crops are established permanent application of fertilizers is needed. This lowers the cost efficiency of the farm . Bad managment will lead to the abandonment of the land which can't be reforested naturally because of the barren soil.

The solutions to the nutrient problem are:1.careful deforestation. The nutrients must be kept in the growing cycle. 2.restore the nutrient balance. Crops must be chosen that will hold the nutrients like the forest does. This calls for multiple crops or agro-forestry, planting crops and trees. 3.Reforestation of devastated areas. These areas will grow as unprotected soil is eroded away.

Physical erosion after deforestation is a big problem in all parts of the humid tropics. After the land is cleared it becomes highly susceptible to the kinetic energy of tropical storms. In forested areas high rainfall interception and surface detention, relatively high evapotranspiration (gaseous water loss due to evaporation and plant transpiration) and extraction of soil moisture from the subsoil by deep rooted plants keep water runoff and baseflow to a minimum (Lal, 1983). Deforestation decreases organic matter and the relative proportion of retention pores in the soil limiting the soil's storage capacity (Eschner, 1960). Runoff and baseflow are greatly increased so soil erosion greatly increases. In forested land only trace amounts of soil erosion is found, but completely cleared and tilled land looses about 22 tons/ha of soil per year to erosion (Lal,1983). This is quite a difference.

Figure 2 shows the amount of runoff and soil erosion associated with different land clearing techniques.

treatment	basin area (ha)	runoff (mm) 1979	runoff (mm) 1979-81	soil erosion (t/ha) 1979	soil erosion (t/ha) 1979-81
Forest	15	trace	trace	trace	trace
Traditional farming	2.6	3.0	6.6	0.01	0.02
Manual clearing/ no tillage	3.1	16.0	16.1	0.4	o.4
Manual clearing/ convevtional tillage	3.2	54.0	79.7	5.0	9.8
Shear blade clearing/ no tillage	2.7	86.0	104.8	4.0	4.8
Tree pusher-root rake/ notillage	3.2	153.0	170.0	15.0	15.7
tree pusher-root rake/ conventional tillage	4.0	250.0	330.6	20.0	24.3

Figure 2 (Lal,1983).

The chart shows that manual clearing/no tillage is the best soil conservation method. Shear blade/no tillage is also acceptable. The tree pusher-root rake removes all stumps and roots and conventional tillage breaks up the soil making it highly susceptible to erosion. There are a few solutions to the problem of soil erosion. First use of manual clearing or shear blade clearing methods with no tillage. Crop yield will be lower but soil loss will be minimized making the area productive over the long term and thus more profitable.

Seedbed preparation helps reduce tillage to the lowest possible level. Some soils, especially clays won't be very successful without tillage but coarse soils especially where worked by fauna such as earthworms will be successful with no tillage. Leave the soil surface rough and add a crop residue mulch and vegetative cover. These increase the soils resistance

to flow.

Runoff managment also reduces soil loss. On slopped fields terraces help prevent loss of soil due to downslope movement. They decrease the velocity of water runoff and encourage deposition. Unterraced basins can lose up to 3 times as much soil per year as terraced basins (Lal, 1983). On the negative side terraces are expensive and require a lot of maintence. They have been successful in the more mountainous areas of Brazil and southeast Asia. A cheaper alternative is the combination of drainage ditches and grasses to stabalize slopes. These must be well designed or they can cause even more damage than if they were'nt there (Liang, 1983).

Another way to control soil loss is to choose the right crops to protect the soil. Its clear that some crops are better for soil conservation than others. Good crops to use grow quickly early in the season to provide ground cover and maintain a good canopy during periods of heavy rain. Single crops don't give as good ground cover as mixed crops. Some of the best covering crops have an open canopy during the first 3 to 4 months of growth so another crop is needed to fill this early growth gap. Cassava(a woody plant with milky sap from which tapioca is made)/sweet potato and cassava/maize combinations provide the best ground cover. They cover about 85% of the ground. Cassava alone covers 55% of the ground (Lal, 1983).

Use of perenials to canopy the soil is another good combination with crops. Trees with deep roots work the best. In Brazil combination pasture/orchard worked well until the

grass was destroyed by overgrazing. Replacement of unproductive local varieties of trees with productive plantation trees and shrubs(coffee, cocoa, rubber etc.)has been successful in parts of Brazil also(Lal, 1983). This takes a long term committment and importation and testing of various types of plants in some areas such as southeast Asia.

One of the fastest growing problems for third world countries is the ruining of water resources by industry. In order to develop they must foster industry so most less developed countries have lenient pollution laws. Tailings from mining operations discharged into the Klang River in Malaysia have made it impassable and have damaged cultivated land downstream. Small scale industry such as electroplating , battery production and metal industries are notorious for dumping over 12 tons of heavy metals into Bankok's waterways. The solution to this problem is not very straightforward. Pollution controls must be adopted by local industry and government but these countries lack technically trained people and space making disposal of hazardous wastes very expensive. (Lesaca, 1983).

With water treatment being expensive and pollutants more common, potable water is becoming harder to get in the populated areas. A solution to this may be the little used resource of groundwater. In the humid tropics the only place groundwater is used are the areas that have severe dry seasons. Because of low amounts of use not much is known about location, size and recharge rates of aquifers (Mink,1983). One would expect fast recharge rates because of the great amount of precipitation.

Conclusions

Third world countries face some tough problems in water managment especially in regards to soil erosion and pollution. These problems are not insurmountable though. A lot of information is now known about water managment that can really help these developing countries support a growing population and turn unproductive land into useful farms and forests. The managment techniques just have to be studied and put into use to begin to turn these countries' situations of loss and devastation into production.

References

Brinkmann,W.F.L., Nutrient balance of a central Amazonian rainforest: comparison af natural and man-managed systems. in Hydrology of Humid Tropical Regions. ed. by Reiner Keller, IAHS Publication #140, 1983.

Echolm, E. (1979) Planting for the Future: Forestry and Human Needs. World Watch Paper no. 26. World Watch Institute

Eschner,A.R. (1960) Effect of scrub oak and associated ground cover on soil moisture. USDA FS Sta. Pap. no.133.

Lal,R., (1983) Soil Erosion in the humid tropics with particular reference to agricultural land development and soil conservation. in Hydrology of Humid Tropic Regions. ed. by Reiner Keller, IAHS Publication #140.

Lesaca, Reynaldo (1983) Water resources development and mangment efforts in Asia and the Pacific. in Hydrology of Humid Tropical Regions. ed. by Reiner Keller, IAHS Publication #140.

Liang, Sheng Lewis, (1983) Selection of soil and water conservation practices for a giant bamboo plantation in Taiwan. in Hydrology of Humid Tropic Regions . ed. by Reiner Keller, IAHS Publication #140.

Mink,John F., (1983) Groundwater hydrology in agriculture of the humid tropics. in Hydrology of Humid Tropic Regions. ed. by Reiner Keller, IAHS Publication #140.

UNESCO (1978) World Water Balance and Water Resources of the Earth. Studies and Reports in Hydrology no.25 UNESCO, Paris,France.

Volker, A., (1983) Rivers of southeast Asia: their regime, utilization and regulation. in Hydrology of Humid Tropical Regions. ed. by Reiner Keller, IAHS Publication #140.